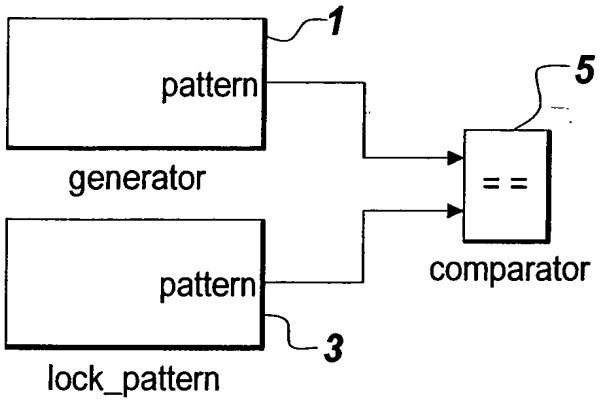


Fig. 1

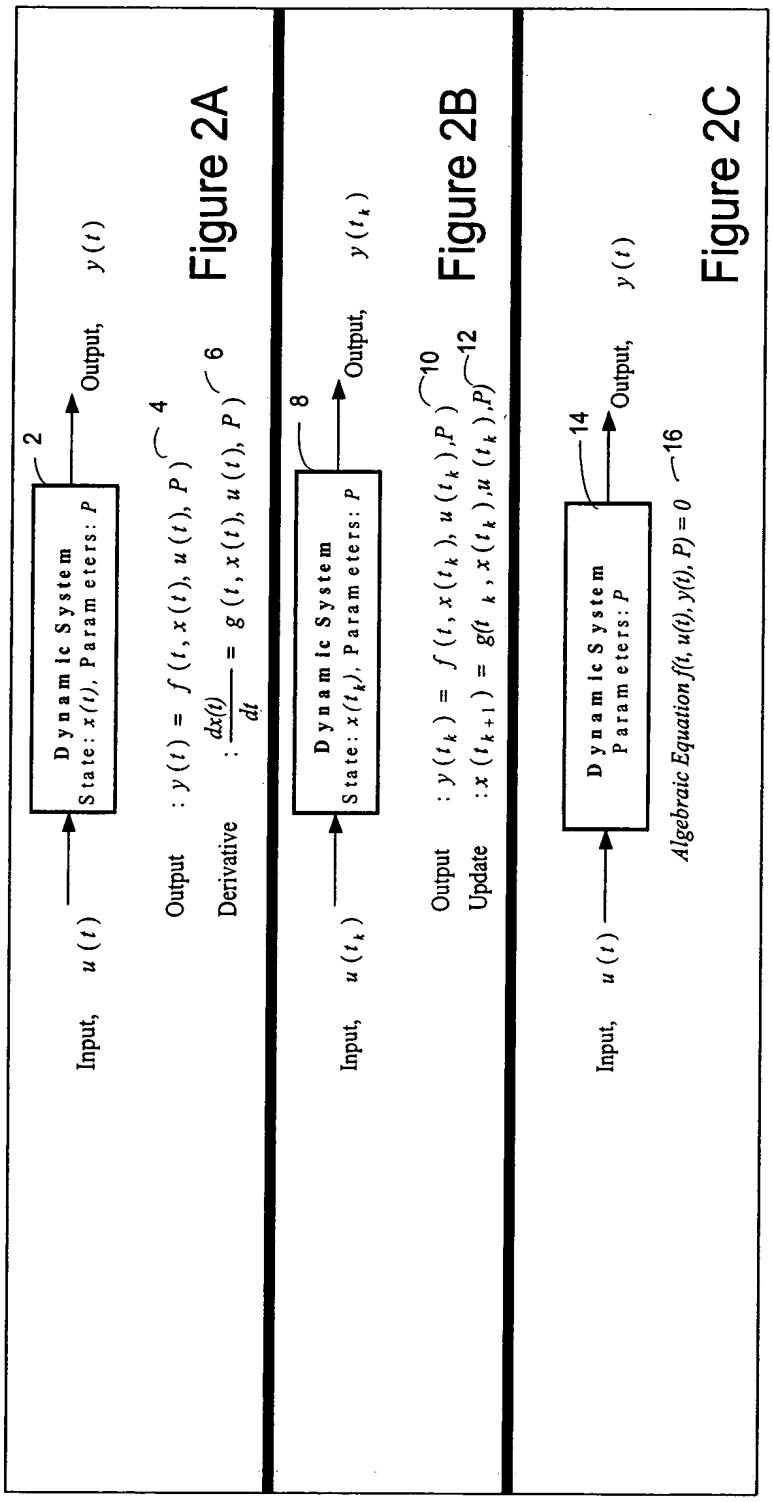

Input, $u(t)$
Dynamic System
State: $x(t)$, Parameters: P
2
Output, $y(t)$
Output : $y(t) = f(t, x(t), u(t), P)$ 4
Derivative : $\frac{dx(t)}{dt} = g(t, x(t), u(t), P)$ 6
Figure 2A
Input, $u(t_k)$
Dynamic System
State: $x(t_k)$, Parameters: P
8
Output, $y(t_k)$
Output : $y(t_k) = f(t, x(t_k), u(t_k), P)$ 10
Update : $x(t_{k+1}) = g(t_k, x(t_k), u(t_k), P)$ 12
Figure 2B
Input, $u(t)$
Dynamic System
Parameters: P
14
Output, $y(t)$
Algebraic Equation $f(t, u(t), y(t), P) = 0$ 16
Figure 2C

Figure 3

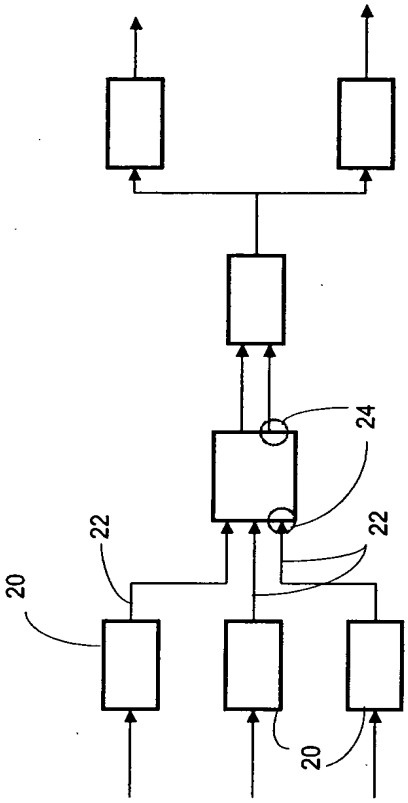


Figure 4

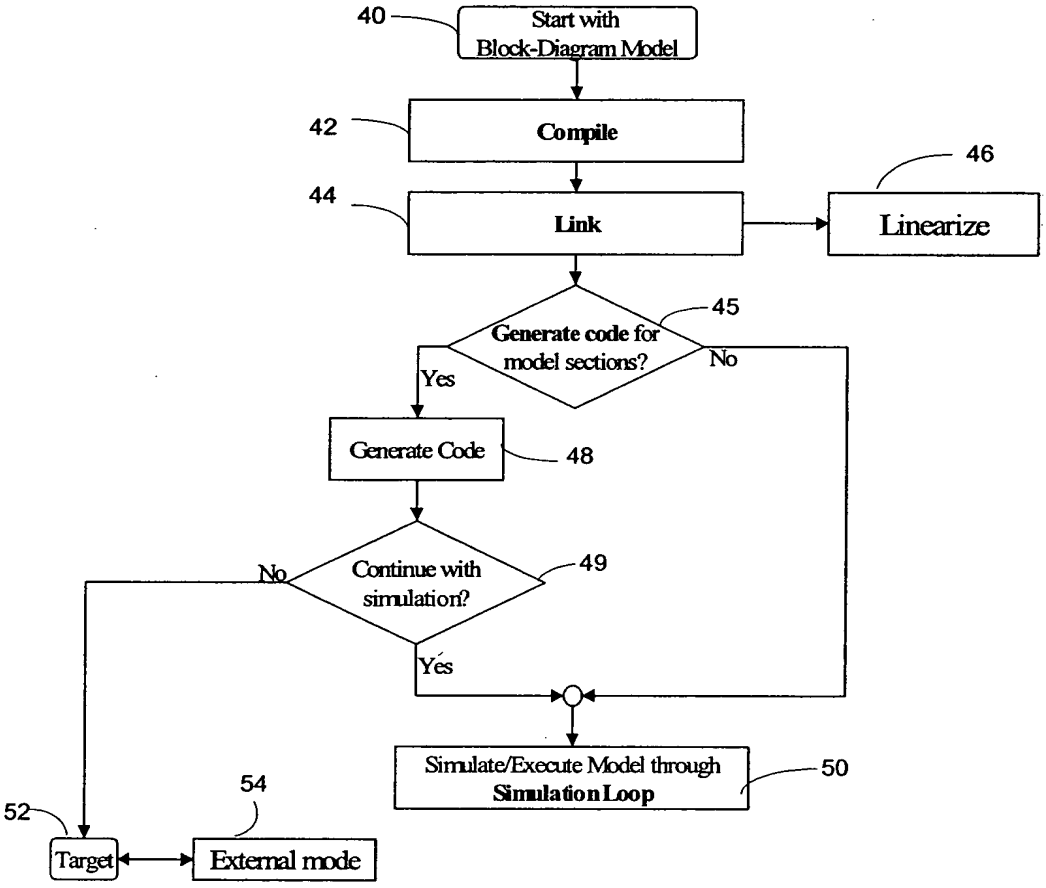

40
Start with Block-Diagram Model
42
Compile
44
Link
46
Linearize
45
Generate code for model sections?
Yes
No
Generate Code
48
Continue with simulation?
49
No
Yes
Simulate/Execute Model through Simulation Loop
50
52
Target
54
External mode

Figure 5

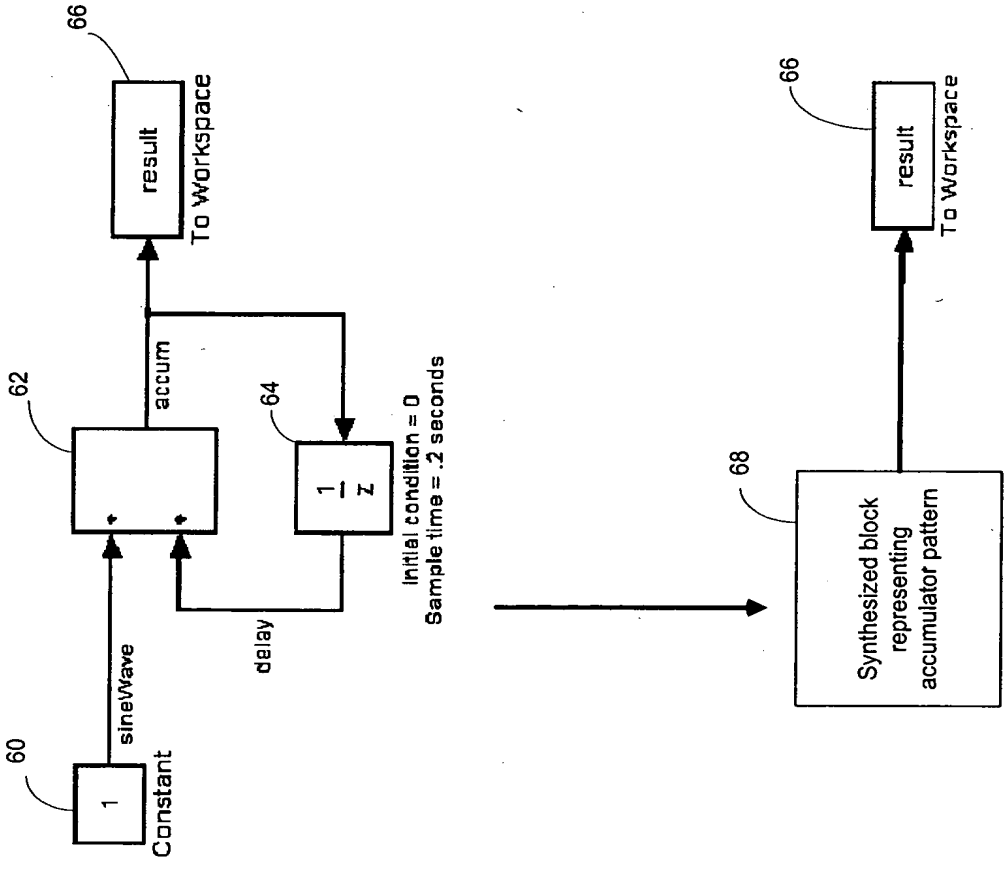

66
result
To Workspace
accum
62
64
1
z
Initial condition = 0
Sample time = .2 seconds
delay
60
1
sineWave
Constant
66
result
To Workspace
68
Synthesized block representing accumulator pattern

Figure 6A

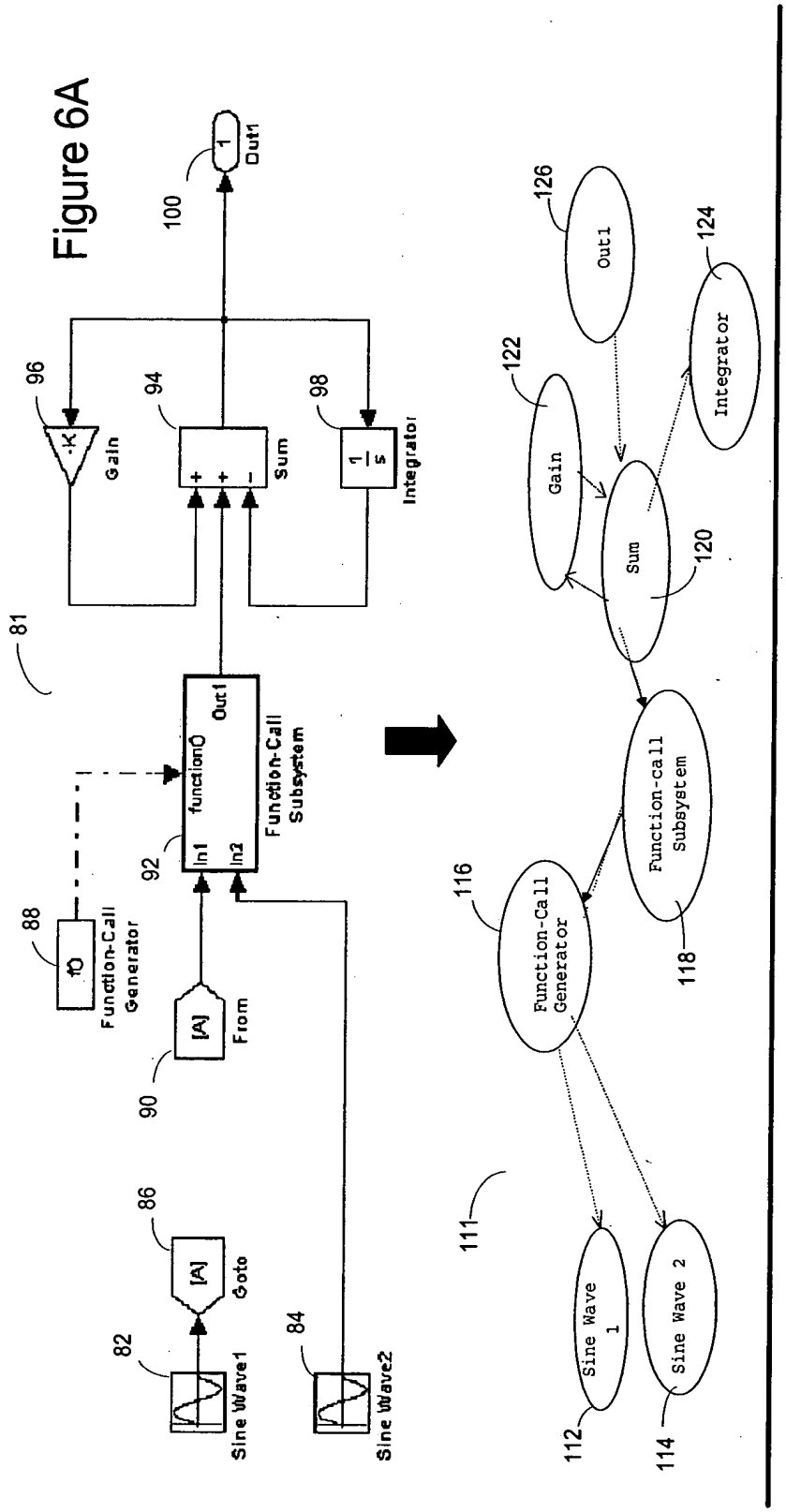


Figure 6B

Sorted List:

128

```
0:0 Sine Wave 1
0:1 Sine Wave 2
0:2 Function-Call Generator
0:3 Function-Call Subsystem
0:4 Integrator
0:5 Gain (algebraic id 0#1)
0:6 Sum  (algebraic variable for id 0#1)
0:7 Out1
```

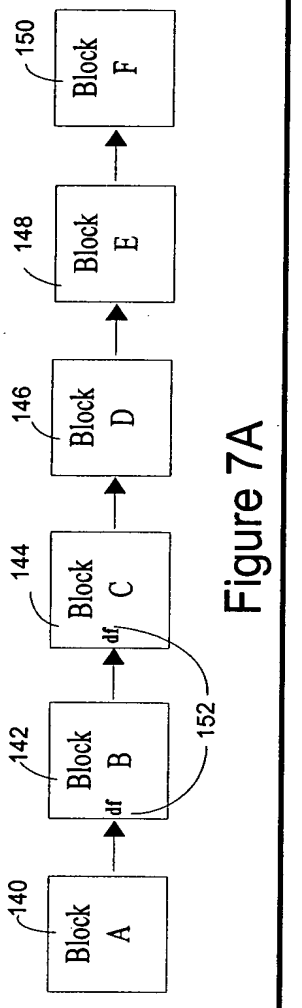


Figure 7A

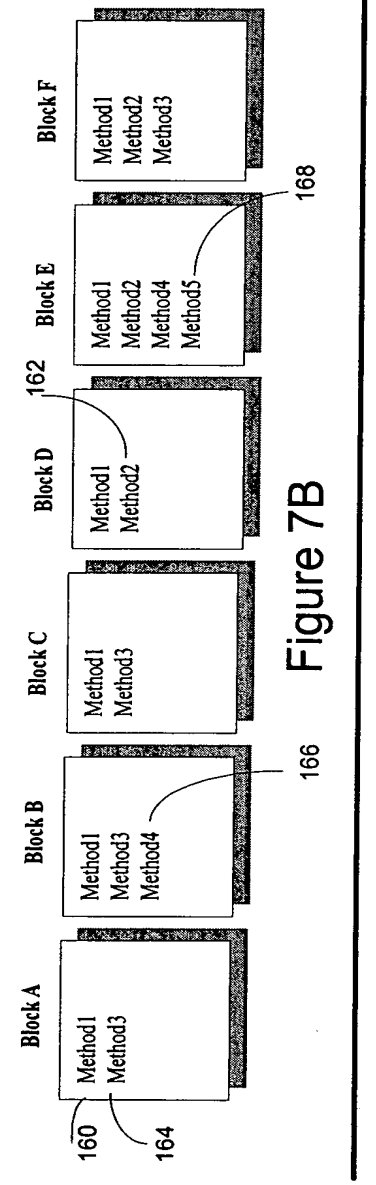


Figure 7B

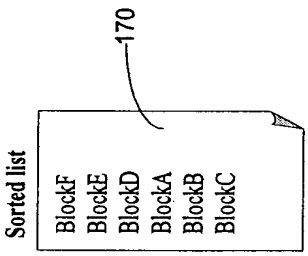


Figure 7C

Figure 8

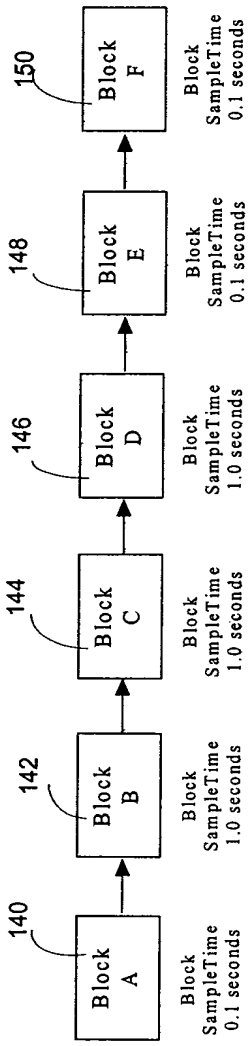

140
Block A
Block SampleTime 0.1 seconds
142
Block B
Block SampleTime 1.0 seconds
144
Block C
Block SampleTime 1.0 seconds
146
Block D
Block SampleTime 1.0 seconds
148
Block E
Block SampleTime 0.1 seconds
150
Block F
Block SampleTime 0.1 seconds

Figure 9

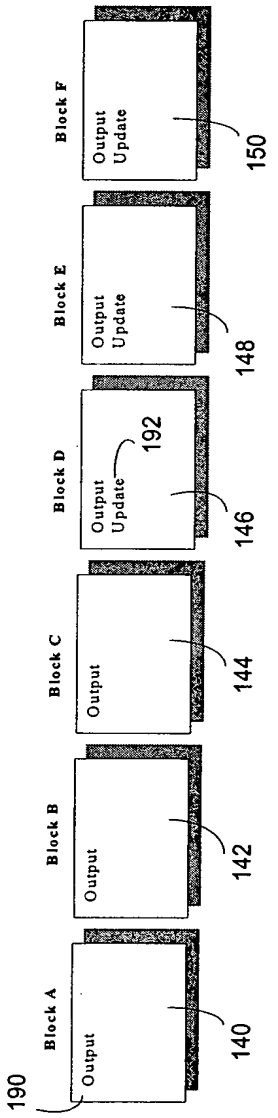

Block A
Output
140
Block B
Output
142
Block C
Output
144
Block D
Output
Update
192
146
Block E
Output
Update
148
Block F
Output
Update
150
190

Figure 10

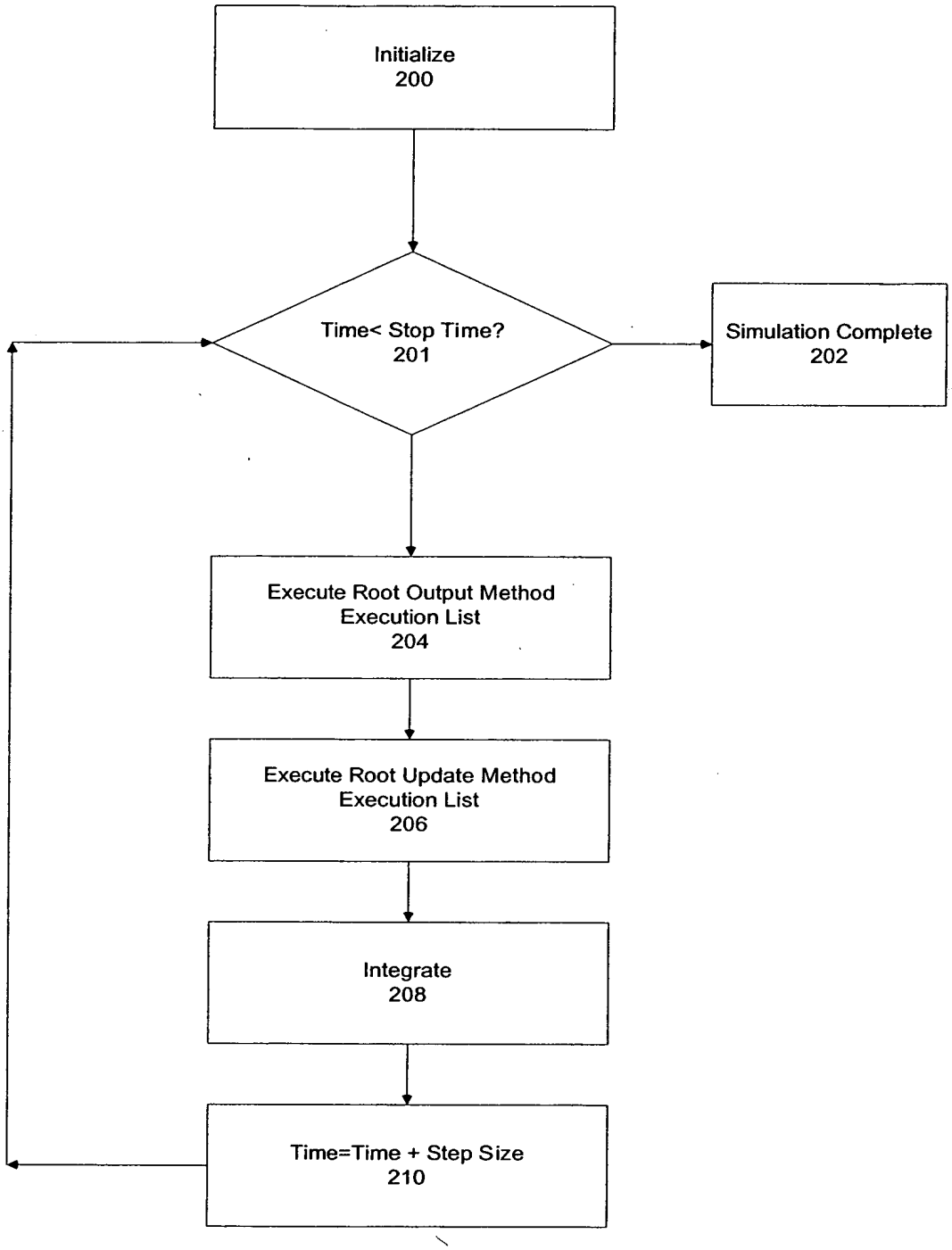

Initialize
200
Time< Stop Time?
201
Simulation Complete
202
Execute Root Output Method Execution List
204
Execute Root Update Method Execution List
206
Integrate
208
Time=Time + Step Size
210

Figure 11A

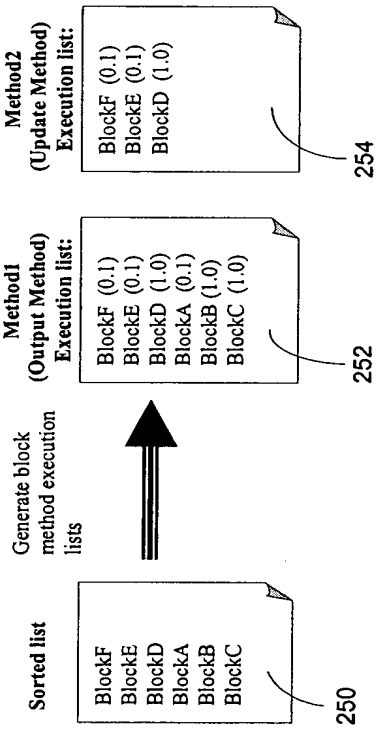

Sorted list
BlockF
BlockE
BlockD
BlockA
BlockB
BlockC
250
Generate block method execution lists
Method1 (Output Method) Execution list:
BlockF (0.1)
BlockE (0.1)
BlockD (1.0)
BlockA (0.1)
BlockB (1.0)
BlockC (1.0)
252
Method2 (Update Method) Execution list:
BlockF (0.1)
BlockE (0.1)
BlockD (1.0)
254

Figure 11B

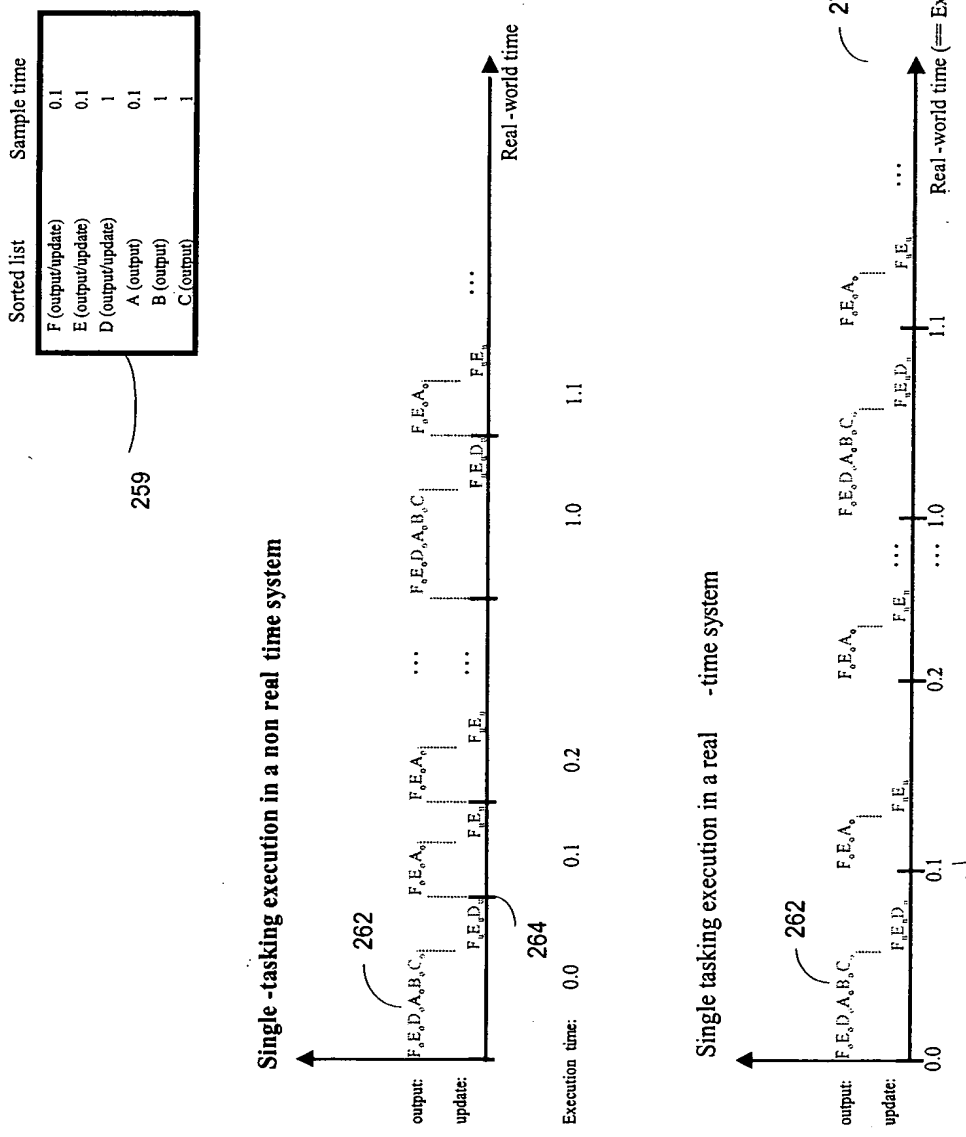

Sorted list
Sample time
F (output/update) 0.1
E (output/update) 0.1
D (output/update) 1
A (output) 0.1
B (output) 1
C (output) 1
259
260
Real - world time
Single - tasking execution in a non real time system
262
264
output:
update:
Execution time: 0.0 0.1 0.2 1.0 1.1
270
Real - world time (== Execution Time)
Single tasking execution in a real - time system
wait
0.0 0.1 0.2 1.0 1.1

Figure 12A

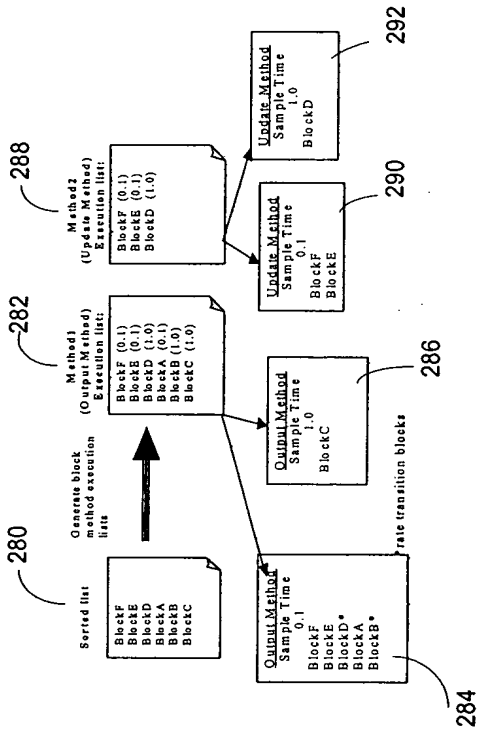

280
Sorted list
BlockF
BlockE
BlockD
BlockA
BlockB
BlockC
Generate block method execution lists
282
Method1
(Output Method)
Execution list:
BlockF (0.1)
BlockE (0.1)
BlockD (1.0)
BlockA (0.1)
BlockB (1.0)
BlockC (1.0)
288
Method2
(Update Method)
Execution list:
BlockF (0.1)
BlockE (0.1)
BlockD (1.0)
Output Method
Sample Time
0.1
BlockF
BlockE
BlockD*
BlockA
BlockB*
284
Output Method
Sample Time
1.0
BlockC
286
Update Method
Sample Time
0.1
BlockF
BlockE
290
Update Method
Sample Time
1.0
BlockD
292
rate transition blocks

Figure 12B

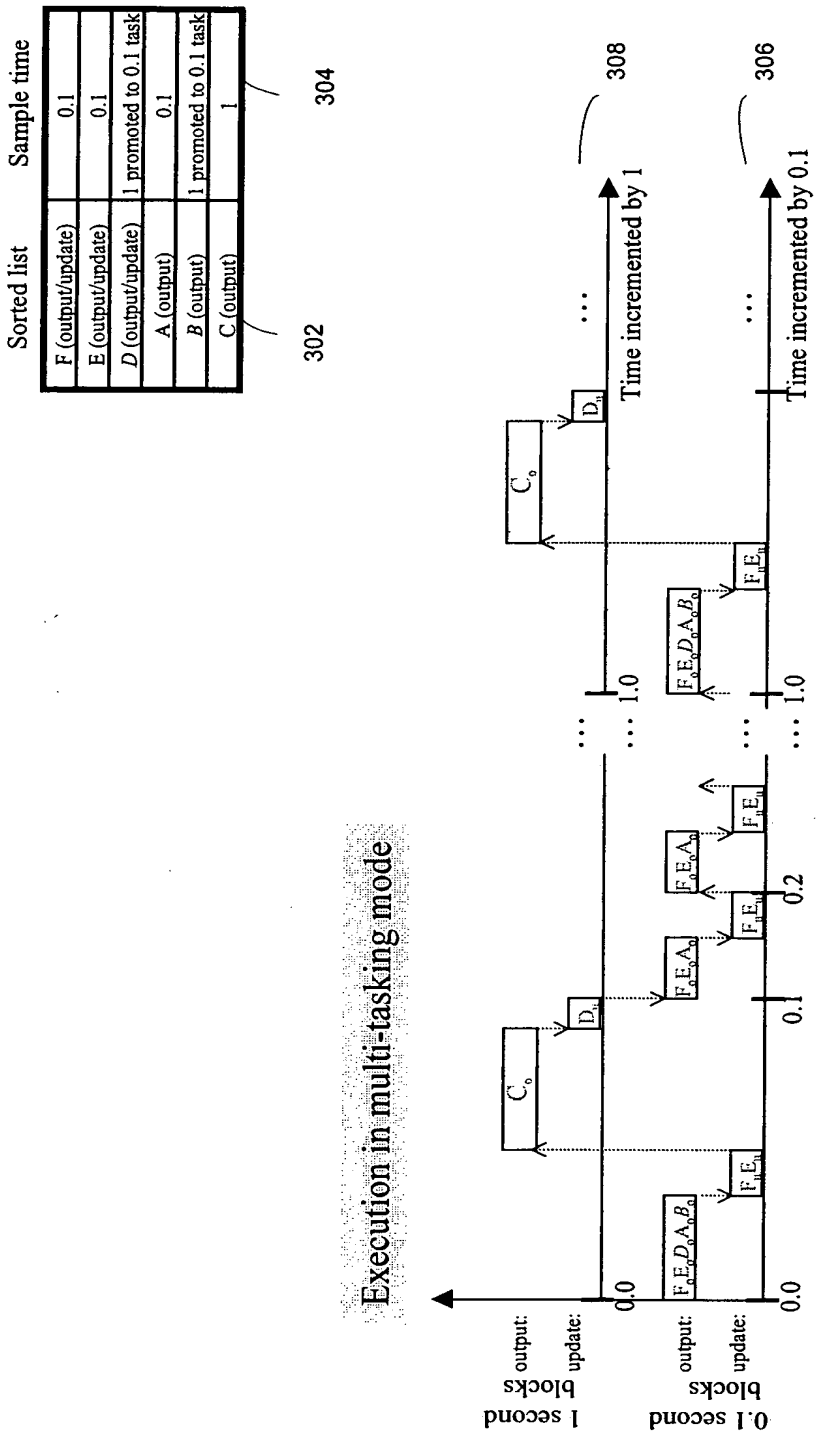

Sorted list
Sample time
F (output/update)
0.1
E (output/update)
0.1
D (output/update)
1 promoted to 0.1 task
A (output)
0.1
B (output)
1 promoted to 0.1 task
C (output)
1
302
304
Execution in multi-tasking mode
0.1 second blocks
1 second blocks
output:
update:
0.0
0.1
0.2
1.0
Time incremented by 0.1
Time incremented by 1
306
308

Figure 13

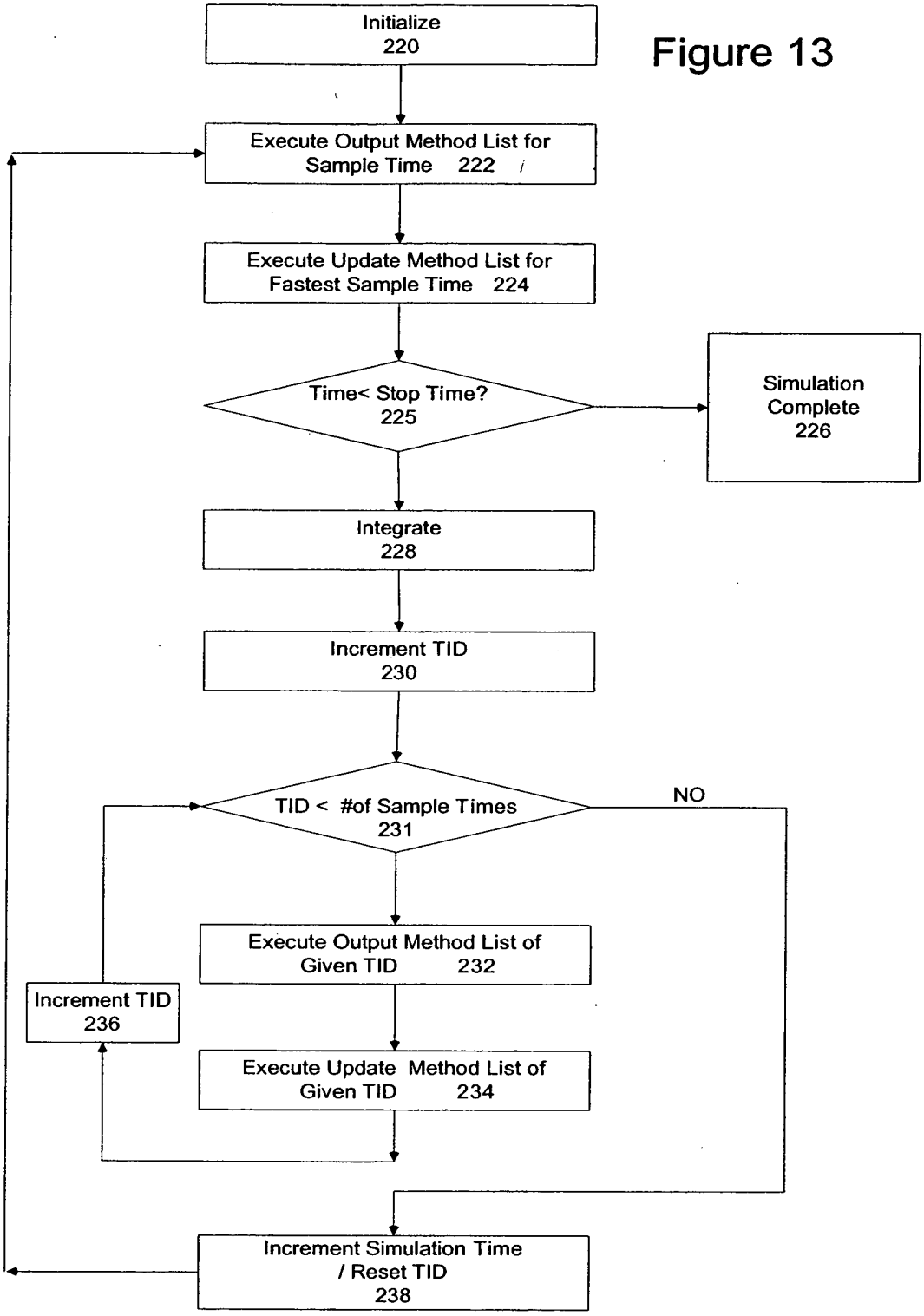
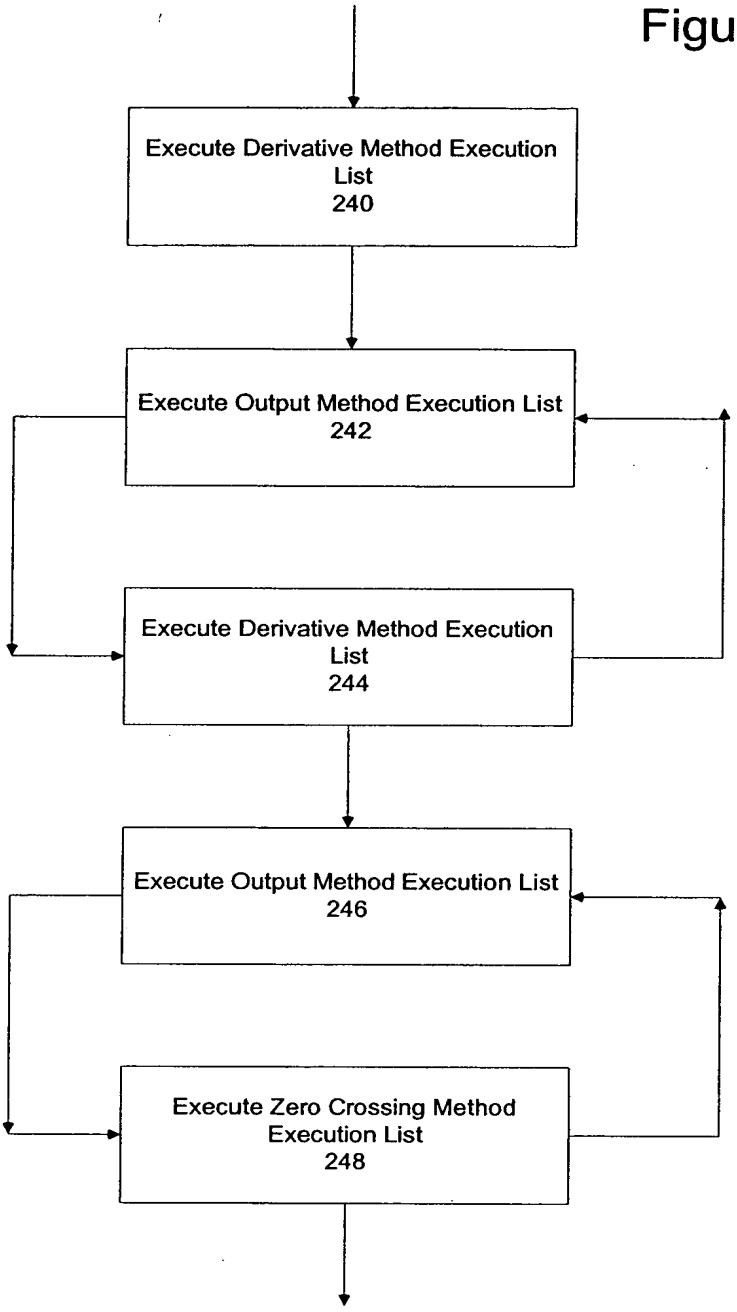

Initialize
220
Execute Output Method List for Sample Time 222
Execute Update Method List for Fastest Sample Time 224
Time< Stop Time?
225
Simulation Complete
226
Integrate
228
Increment TID
230
TID < #of Sample Times
231
NO
Execute Output Method List of Given TID 232
Execute Update Method List of Given TID 234
Increment TID
236
Increment Simulation Time / Reset TID
238

Figure 14


Execute Derivative Method Execution List
240
Execute Output Method Execution List
242
Execute Derivative Method Execution List
244
Execute Output Method Execution List
246
Execute Zero Crossing Method Execution List
248

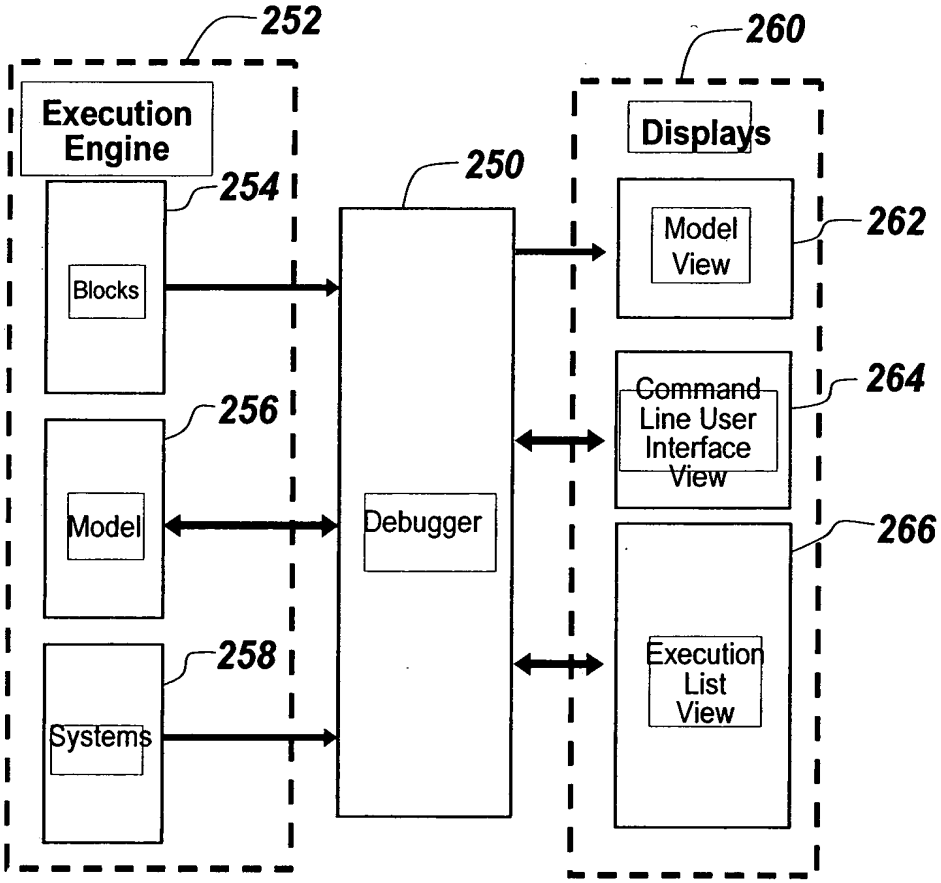

252
Execution Engine
254
Blocks
256
Model
258
Systems
250
Debugger
260
Displays
Model View
262
Command Line User Interface View
264
Execution List View
266

Fig. 15

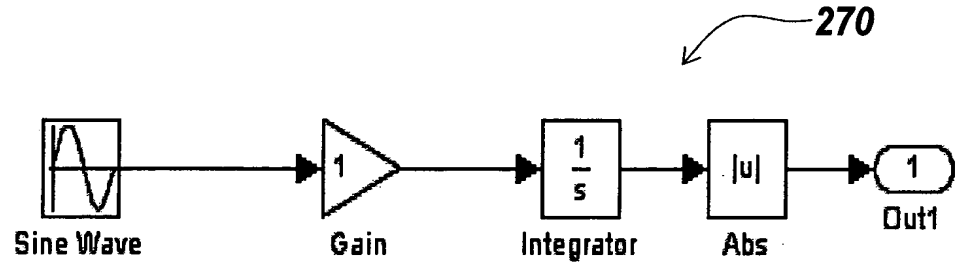


Fig. 16A

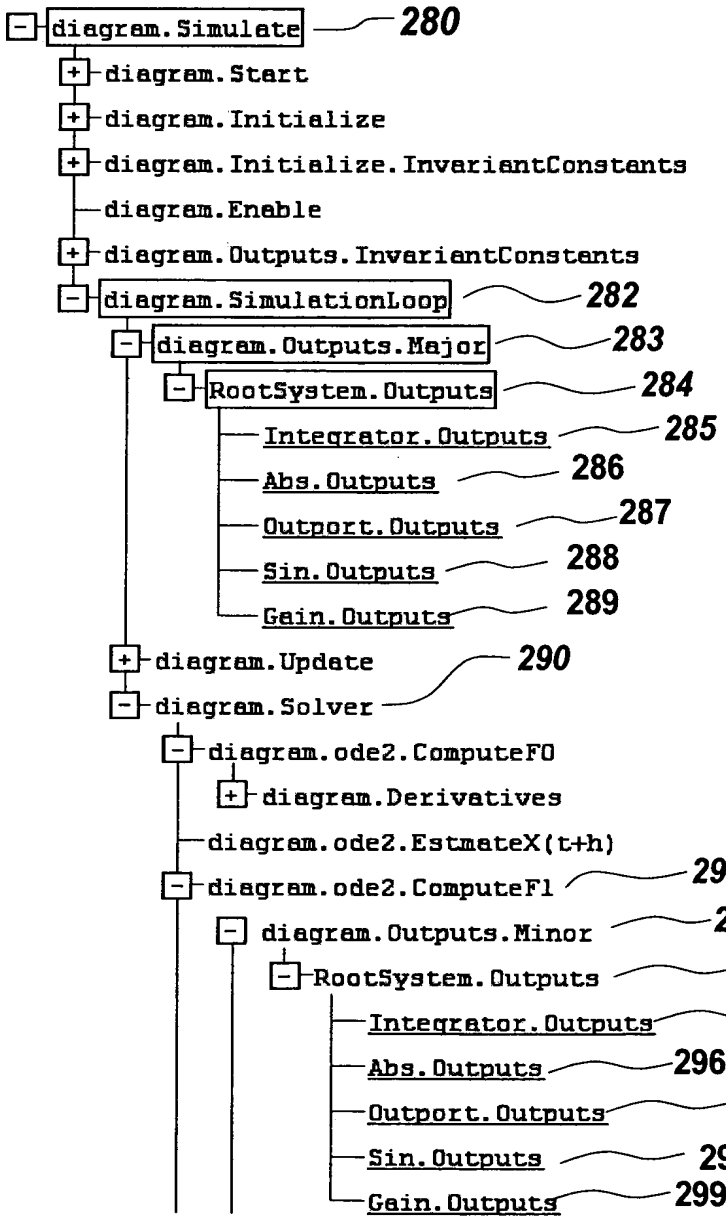


Fig. 16B

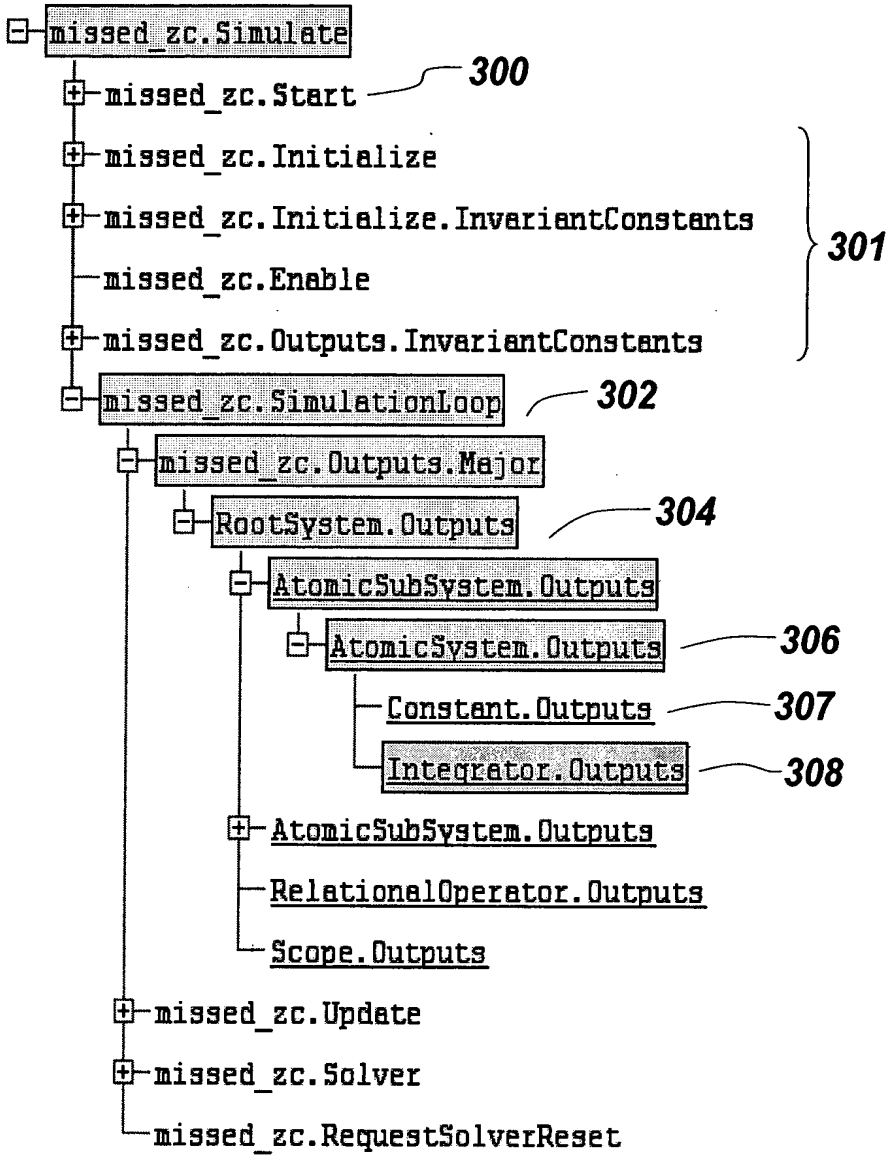

missed_zc.Simulate
missed_zc.Start
300
missed_zc.Initialize
missed_zc.Initialize.InvariantConstants
missed_zc.Enable
missed_zc.Outputs.InvariantConstants
301
missed_zc.SimulationLoop
302
missed_zc.Outputs.Major
RootSystem.Outputs
304
AtomicSubSystem.Outputs
AtomicSystem.Outputs
306
Constant.Outputs
307
Integrator.Outputs
308
AtomicSubSystem.Outputs
RelationalOperator.Outputs
Scope.Outputs
missed_zc.Update
missed_zc.Solver
missed_zc.RequestSolverReset

Fig. 17

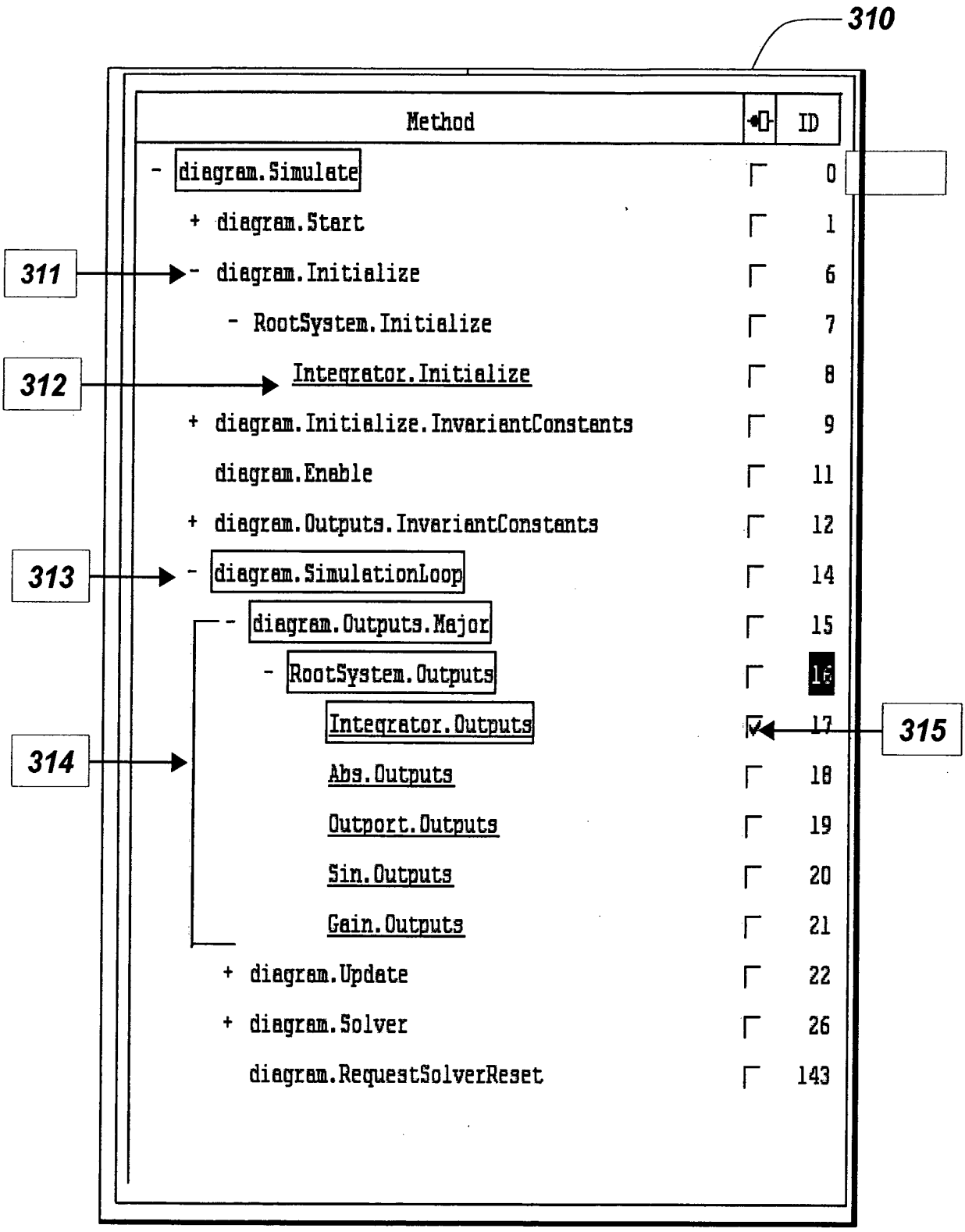

310
Method
ID
- diagram.Simulate 0
+ diagram.Start 1
311
- diagram.Initialize 6
- RootSystem.Initialize 7
312
Integrator.Initialize 8
+ diagram.Initialize.InvariantConstants 9
diagram.Enable 11
+ diagram.Outputs.InvariantConstants 12
313
- diagram.SimulationLoop 14
- diagram.Outputs.Major 15
- RootSystem.Outputs 16
Integrator.Outputs 17
315
314
Abs.Outputs 18
Outport.Outputs 19
Sin.Outputs 20
Gain.Outputs 21
+ diagram.Update 22
+ diagram.Solver 26
diagram.RequestSolverReset 143

Fig. 18A

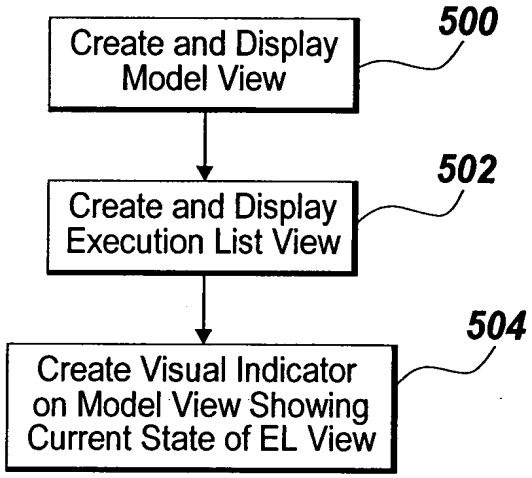

Create and Display Model View
500
Create and Display Execution List View
502
Create Visual Indicator on Model View Showing Current State of EL View
504

Fig. 18B

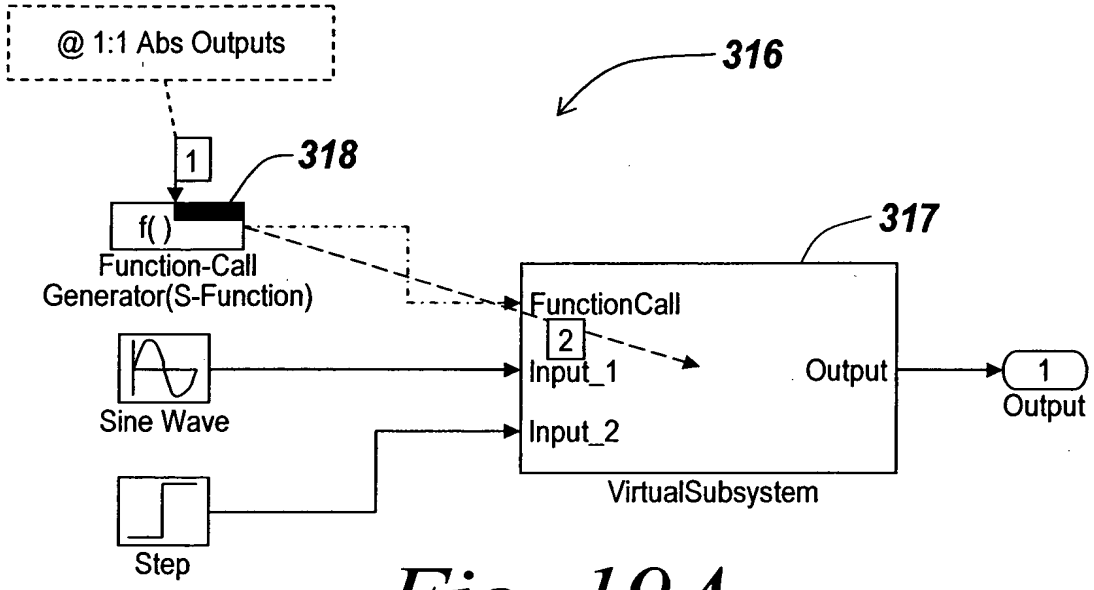


Fig. 19A

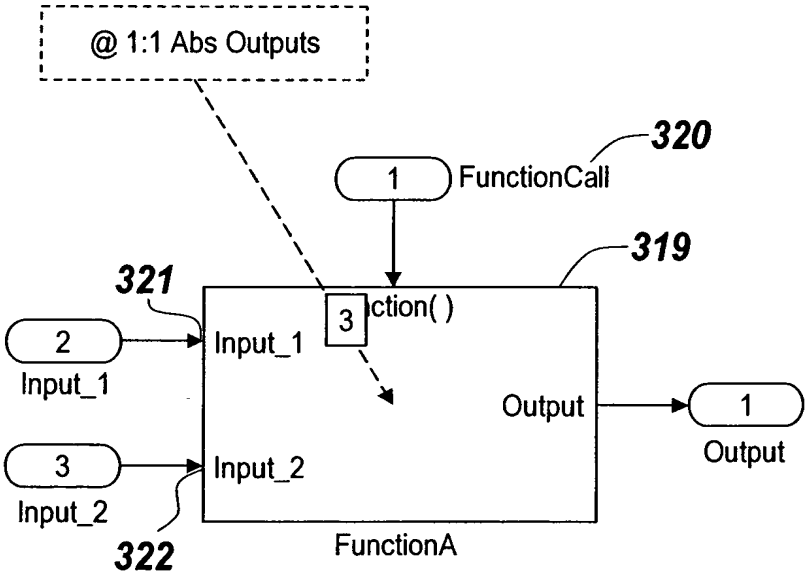


Fig. 19B

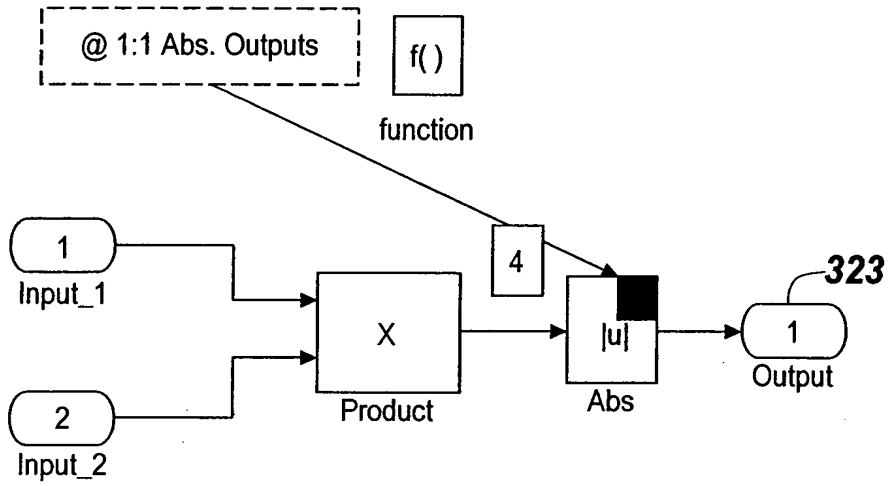


Fig. 19C

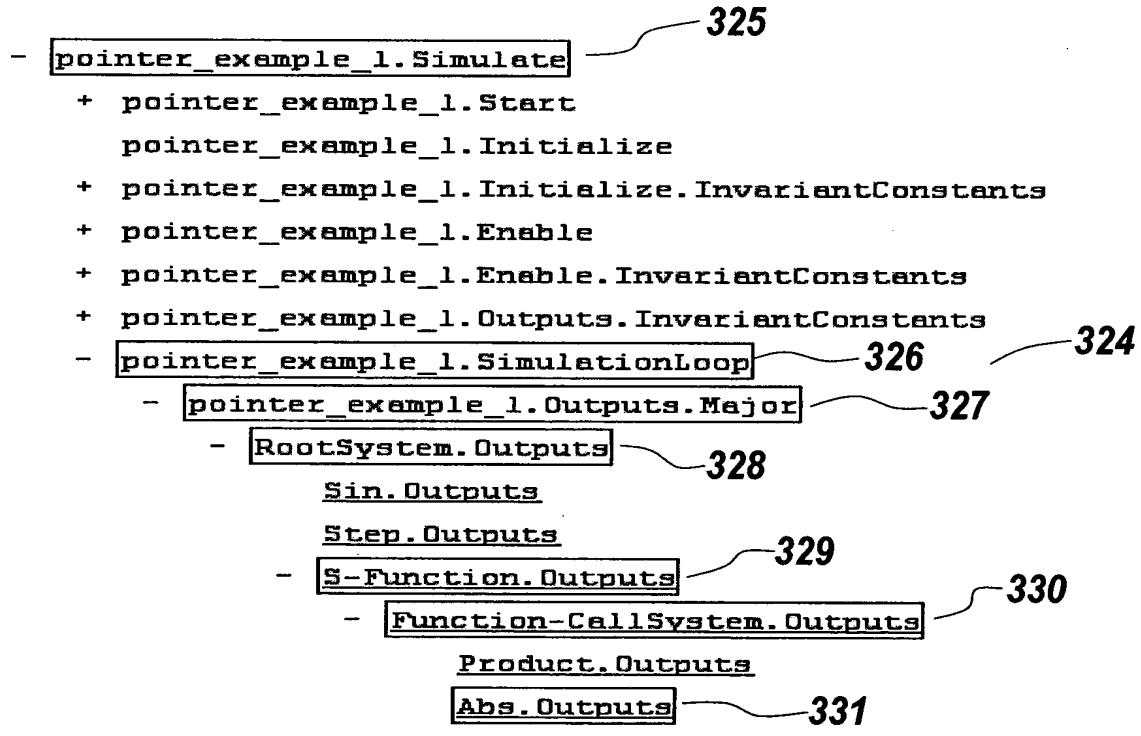


Fig. 19D

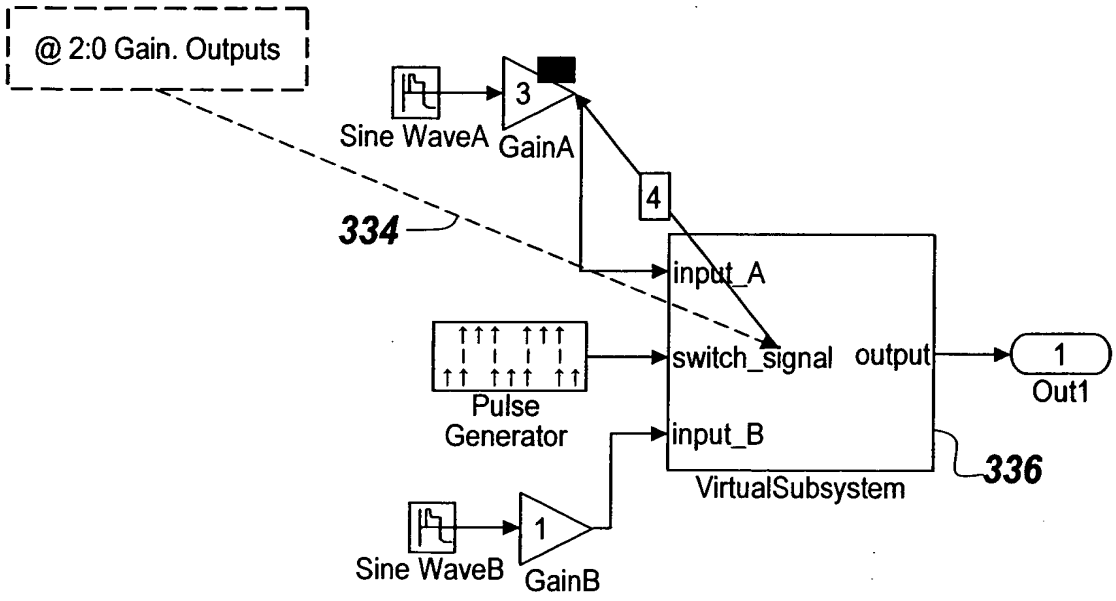


Fig. 20A

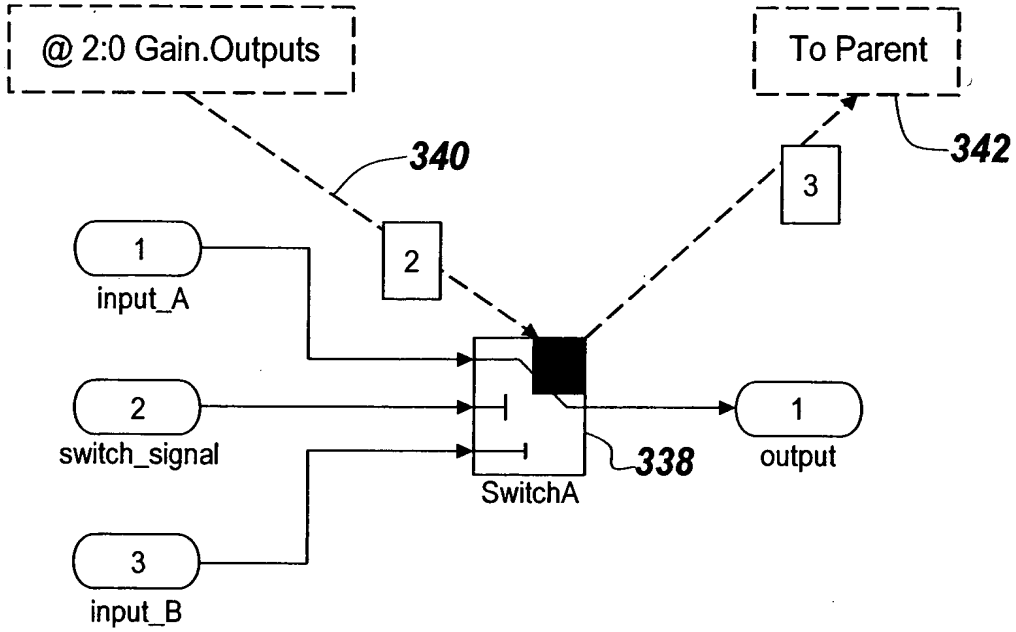


Fig. 20B

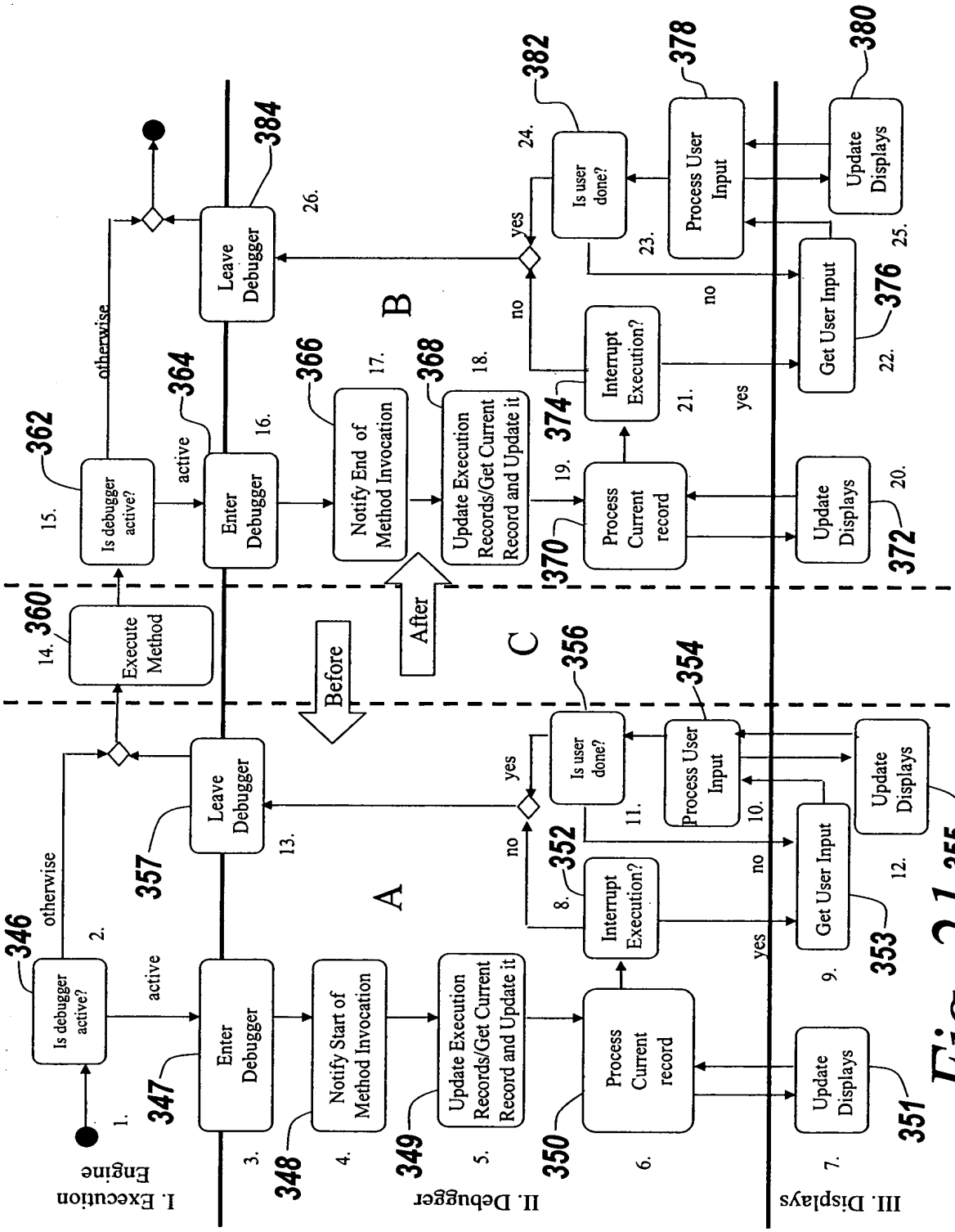

I. Execution Engine
II. Debugger
III. Displays
Is debugger active?
Enter Debugger
Notify Start of Method Invocation
Update Execution Records/Get Current Record and Update it
Process Current record
Interrupt Execution?
Get User Input
Update Displays
Is user done?
Process User Input
Leave Debugger
Execute Method
Notify End of Method Invocation
otherwise
active
yes
no
Before
After
A
B
C
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
346
347
348
349
350
351
352
353
354
355
356
357
360
362
364
366
368
370
372
374
376
378
380
382
384

Fig. 21

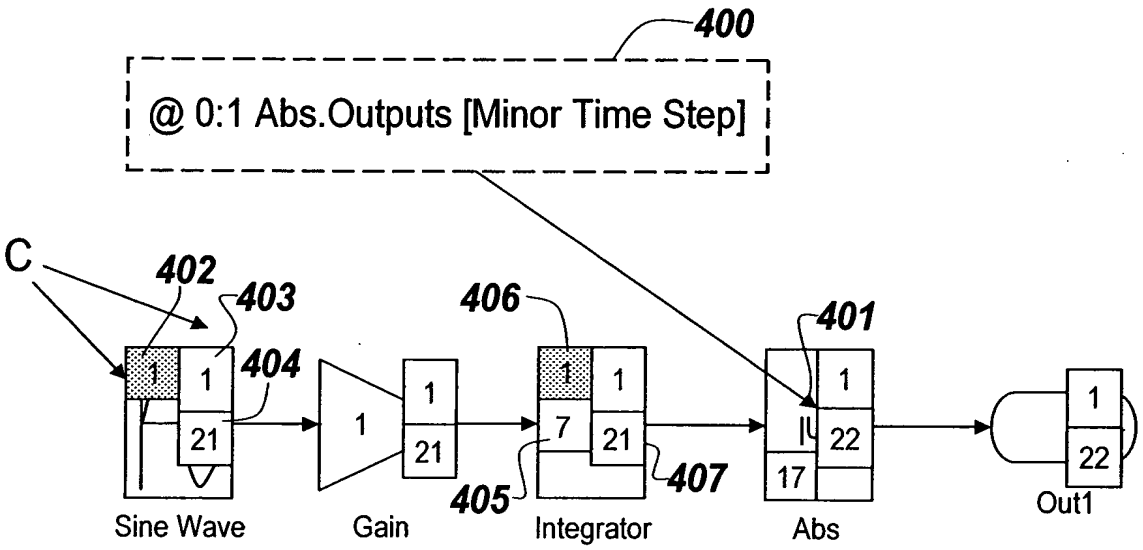

400
@ 0:1 Abs.Outputs [Minor Time Step]
C
402
403
404
406
401
405
407
1
21
7
17
22
Sine Wave
Gain
Integrator
Abs
Out1

Fig. 22

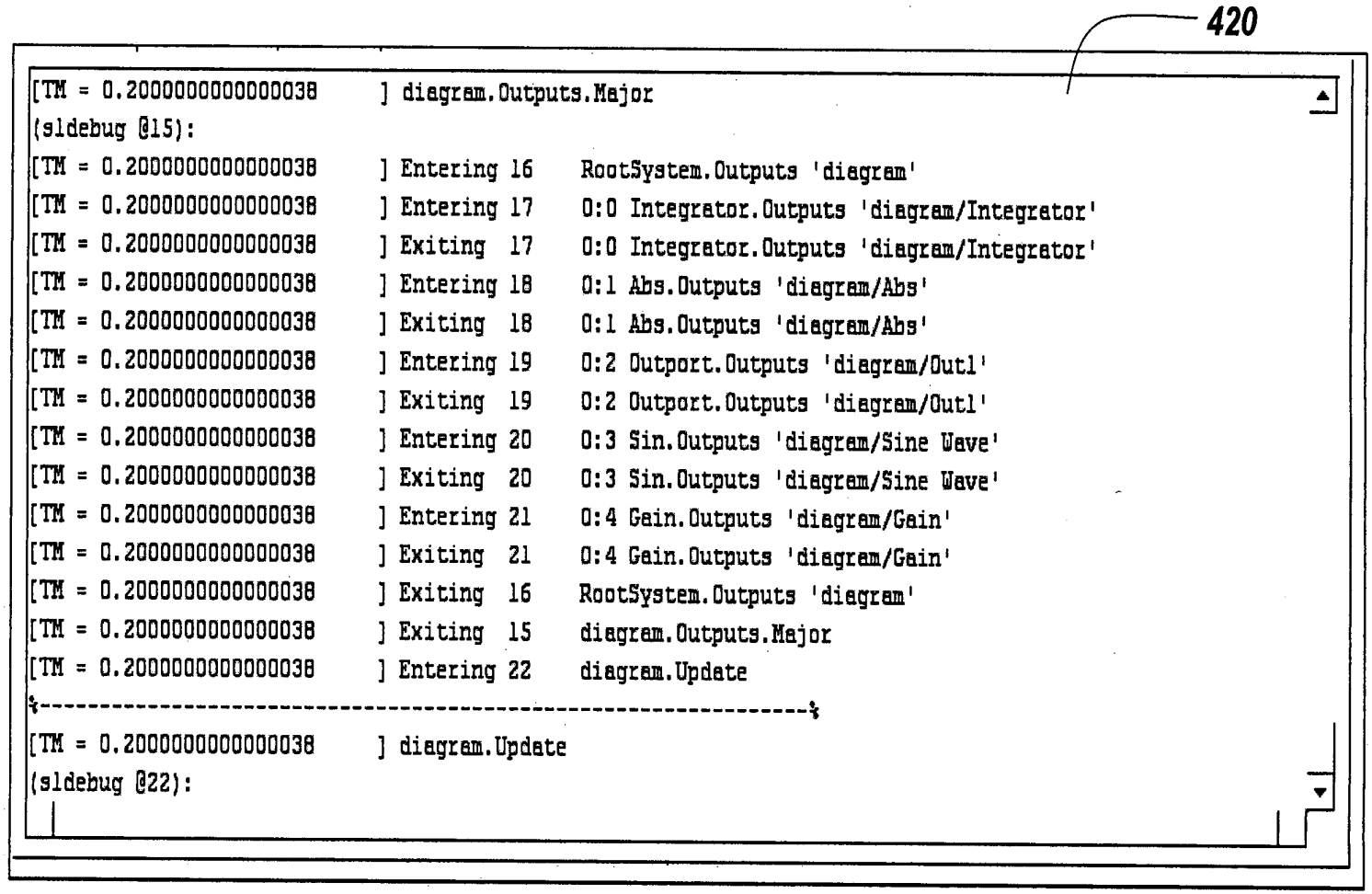


Fig. 23

App No.: Not Yet Assigned
Inventor: Mehmet Yunt et al.
Title: A SYSTEM AND METHOD FOR USING A GRAPHICAL DEBUGGING TOOL IN A MODELING AND EXECUTION ENVIRONMENT
Docket No.: MWS-087
Sheet 27 of 28

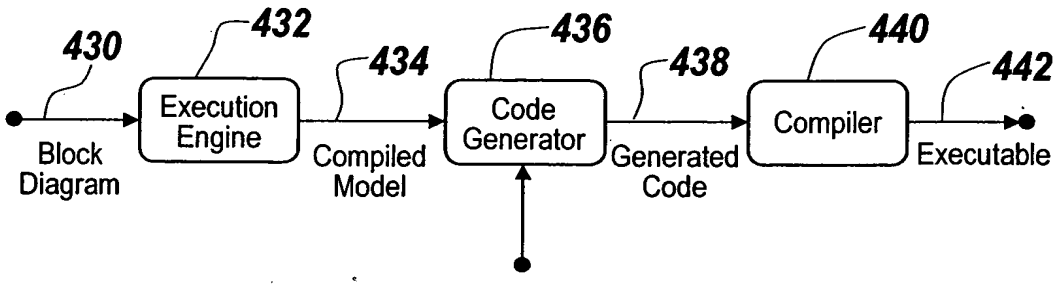

430
432
434
436
438
440
442
Execution Engine
Code Generator
Compiler
Block Diagram
Compiled Model
Generated Code
Executable

Fig. 24

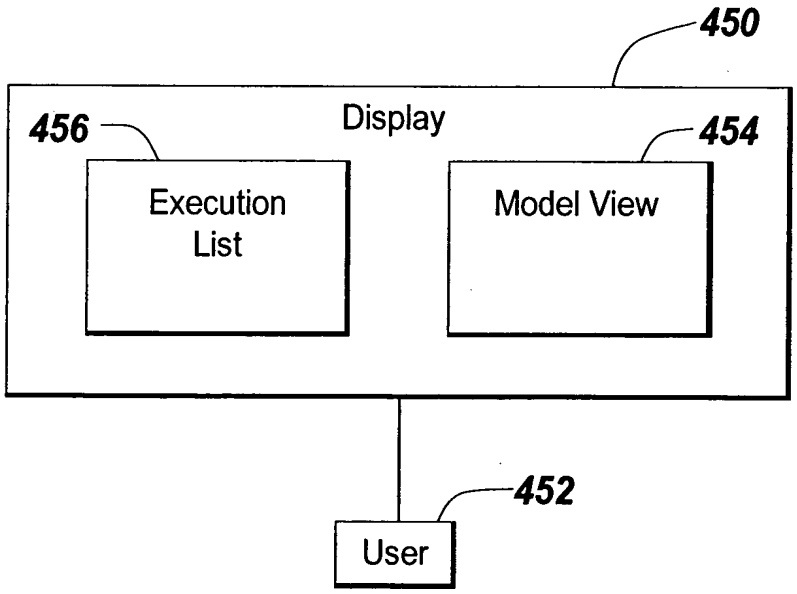

450
Display
456
454
Execution List
Model View
452
User

Fig. 25